The opinion in support of the decision being entered today was *not* written for publication and is *not* binding precedent of the Board.

Paper No. 49

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte DAVID J. BOLL, KENNETH A. LOWE,
WILLIAM T. McCARVILL and MICHAEL R. McCLOY

Appeal No. 2002-0963
Application 08/122,344

ON BRIEF

Before KIMLIN, HANLON, and PAK, *Administrative Patent Judges*.

HANLON, *Administrative Patent Judge*.

DECISION ON APPEAL

This is a decision on an appeal under 35 U.S.C. § 134 from the final rejection of claims 1 through 11 and 14 through 32, all of the claims pending in the application. A decision was previously entered by this panel in the instant application. See Decision on Appeal No. 95-1806 entered on July 29, 1998 (Paper No. 25). In that decision, the final rejection of claims 1 through 11 and 14 through 21 was affirmed. However, since our decision set forth a new rationale based on only two of the four references cited in the final rejection, we denominated the affirmance a new ground of rejection under 37 CFR § 1.196(b). Appellants amended claims 1 through 11 and 14 through 21, and the application was remanded to the examiner pursuant to 37 CFR § 1.196(b). This appeal involves amended claims 1 through 11 and 14 through 21 as well as newly added claims 22 through 32.

The claims on appeal are directed to a method of producing substantially cured fiber reinforced lamination *in situ*. Claim 1 is representative and reads as follows:

1. A method of producing substantially cured fiber reinforced lamination in situ while laying up at least one thermoset resin impregnated fiber tow or tape on a mandrel, comprising:

passing the at least one thermoset resin impregnated fiber tow or tape through a preheating zone of a fiber placement apparatus to preheat the thermoset resin impregnated fiber tow or tape to a predetermined temperature based on the particular thermoset resin so as to partially advance curing of the thermoset resin; and

laying up on the mandrel the at least one fiber tow or tape impregnated with the thermoset resin in a preheated state and exhibiting a partially advanced cure while simultaneously advancing the curing of the thermoset resin to substantial completion of greater than 60% crosslink density by:

supplying heat to an area of the mandrel proximate a location of application thereto of the at least one thermoset resin impregnated fiber tow or tape;

monitoring a plurality of parameters associated with application of the at least one thermoset resin impregnated fiber tow or tape by the fiber placement apparatus to the mandrel; and

controlling a degree of advancement of cure of the resin in the at least one thermoset resin impregnated fiber tow or tape as a function of values of at least one of the monitored parameters.

The references relied upon by the examiner are:

Forbes et al. (Forbes)	2,683,105	Jul. 6, 1954
Sherwood	3,313,670	Apr. 11, 1967
Chitwood et al. (Chitwood)	3,574,040	Apr. 6, 1971
Lemelson	3,616,070	Oct. 26, 1971
Boss et al. (Boss)	3,844,822	Oct. 29, 1974
McClean et al. (McClean)	4,145,740	Mar. 20, 1979
Hebert et al.	4,797,172	Jan. 10, 1989
Alenskis et al. (Alenskis)	4,867,834	Sep. 19, 1989
Benson et al. (Benson)	5,045,147	Sep. 3, 1991

Klein, A. J. (Editor), "Automated tape laying," Advanced Composites, pp. 44-52 (Jan/Feb. 1989).

Evans, D. O. et al. (Evans), "Fiber Placement Process Study," SAMPE, 34TH Symposium Book of Proceedings, pp. 1-12 (May 8-11, 1989).

The following rejections are at issue in this appeal:

(1) Claims 1, 3 through 7, 9, 14 through 17, 19, 20 and 22 through 32 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Evans in view of Chitwood, Sherwood, Hebert and Boss.

(2) Claims 2, 19 and 21 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Evans in view of Chitwood,

Sherwood, Hebert and Boss, and further in view of Benson or Alenskis.

(3) Claim 7 is rejected under 35 U.S.C. § 103(a) as being unpatentable over Evans in view of Chitwood, Sherwood, Hebert and Boss, and further in view of McClean.

(4) Claim 8 is rejected under 35 U.S.C. § 103(a) as being unpatentable over Evans in view of Chitwood, Sherwood, Hebert and Boss, and further in view of Klein or Lemelson.

(5) Claims 10, 11, 18 and 22 through 28 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Evans in view of Chitwood, Sherwood, Hebert and Boss, and further in view of Forbes.

(6) Claims 1, 3, 4, 10, 11, 16, 17, 20, 23 through 26 and 28 through 32 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Sherwood in view of Boss.

(7) Claims 2, 19 and 21 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Sherwood in view of Boss, and further in view of Benson or Alenskis.

(8) Claims 5, 6, 7, 9, 14, 15, 18, 22 and 27 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Sherwood in view of Boss, and further in view of Hebert.

(9) Claim 7 is rejected under 35 U.S.C. § 103(a) as being unpatentable over Sherwood in view of Boss, and further in view of McClean.

(10) Claim 8 is rejected under 35 U.S.C. § 103(a) as being unpatentable over Sherwood in view of Boss, and further in view of Klein or Lemelson.

(11) Claims 10, 11, 18 and 22 through 28 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Sherwood in view of Boss, and further in view of Forbes.

Grouping of claims

In their brief, appellants have included a statement that the claims of groups (1), (2), (5), (6), (7), (8) and (11) do not stand or fall together and have explained why claims of each group are believed to be separately patentable. See Brief, pp. 8-9. Therefore, for purposes of this appeal, the claims stand or fall together as set forth on pages 8 through 9 of appellants' brief. See 37 CFR § 1.192(c)(7) (2000).

Discussion

Claim 1 is directed to a method of producing substantially cured fiber reinforced lamination *in situ* while laying up at least one thermoset resin impregnated fiber tow or tape on a mandrel comprising:

a) passing the thermoset resin impregnated fiber tow or tape through a preheating zone of a fiber placement apparatus to preheat the thermoset resin impregnated fiber tow or tape to a predetermined temperature based on the particular thermoset resin so as to partially advance curing of the thermoset resin; and

b) laying up on the mandrel the fiber tow or tape impregnated with the thermoset resin in a preheated state and exhibiting a partially advanced cure while simultaneously advancing the curing of the thermoset resin to substantial completion of greater than 60% crosslink density.

Claim 32, the only other independent claim on appeal, also requires passing at least one thermoset resin impregnated fiber tow or tape through a preheating zone of a fiber placement apparatus prior to laying up the preheated fiber tow or tape on the mandrel.

Appellants define a fiber placement apparatus as follows (Specification, p. 11, line 16-p. 13, line 6):

> Creel fed partially advanced or nonadvanced prepreg tows 10 that are composed of a high temperature resistant, high performance thermoset resin (such as an epoxy resin) having continuous fibers are continually fed into apparatus 1 where a plurality of prepreg tows 10 (i.e., up to five tows in each of upper and lower paths) enter into the preheating zone 2 through vertically and horizontally situated guide rollers 17 and 18 where half of the tows enter in upper and lower

parallel paths; this preheating zone has heating means 3 that heats the tows or tape to a temperature range of 300 to 500°F for partially advancing to cure the fiber. Perforated plates 19 separate the upper and lower paths and evenly distributes the heating gases from heating means 3. Tows 10 are then passed through distribution means which is in the form of comb 4; then the tows are guided through first ribbonizing section 5. In the upper and lower ribbonizing sections 5 the tows are shaped into the desired shape, such as flattened individual tows or as a consolidated band. The individual tows or tape is then guided onto a wedge shaped platform where the tows or tapes meet in a single plane immediately before passing into a second ribbonizing compaction section 6 (Figure 1 only) where the tows or tapes are formed into single band. Although Figures 1 and 2 show embodiments that has [sic, have] ribbonizing sections therein, a ribbonizing section is only optional and not required in other embodiments not shown; this is especially true where tapes are preformed before entering the fiber placement system of this invention for laying down. It should also be noted that the ribbonizing section can be an independent device attached to the system for use therewith. This band then passes to roller 19 and is pressed onto mandrel 22 not shown. At the point where the tows or tape is placed onto the workpiece on the mandrel 22, heating means 7 heats the tows or tape to a higher temperature above 500°F simultaneously as it is being placed on the mandrel to substantially completely cure the resin therein (that is, to cure the resin to greater than 60%).

As depicted schematically in Figure 3, air flow through the heater 7 is controlled by the air flow and controlled device 8. The temperature is maintained by varying the amount of power with the power control and regulating system 9. The resin impregnated fiber is to be heated to a temperature no greater than the melt

> temperature of the matrix resin. This nip point heating is extremely fast (that is, 1 to 2 seconds).
>
> Closed loop control is achieved by monitoring the temperature of the composite on the mandrel 22 with infrared temperature censor [sic, sensor] 15. The temperature, along with fiber speed, as determined by tachometer 16, is processed by controlled computer 10. In addition to the above-mentioned parameters of fiber temperature and speed, the computer determines the amount of air flow and air temperature which is required by assessing requirements of the process as input from the main fiber placement machine controlled computer 11.

According to Evans, before fiber placement, tape laying and filament winding were the only widely used automatic processes for applying unidirectional composite materials to a lay-up mold or mandrel. Page 1, col. 2. Filament winding is the guiding of a continuous fiber band onto the surface of a mandrel in order to achieve a desired fiber path. Page 5, col. 2. A tape laying machine removes prepreg tape from a roll and compacts it onto the surface of a mold. A tape laying machine can also cut the prepreg tape at different angles as it is laying down tape. Page 10, col. 1.

The demand arose for a single process which had the features of both filament winding and tape laying for producing complex shapes automatically. Page 2, col. 1. The fiber placement process was designed to utilize the advantages of both processes. Page 2, col. 1. Specifically (page 2, cols. 1 and 2):

> The fiber placement process has the features necessary for producing complex shapes made from unidirectional composite materials. The fiber placement process is a unique method of laminating prepregged fiber materials onto a complex mandrel or mold. . . . The basic concept behind fiber placement is to combine the differential tow payout speeds of filament winding with the compaction and cut-restart features of tape laying. . . . [D]ifferential payout allows each tow to independently conform to the surface of a complex shape, compaction allows the material to be laminated with less entrapped air, and individual fiber cut-restart makes a variable band width possible.

Evans describes "compaction" as follows (page 4, col. 2):

> Compaction is the action of mechanically pressing the tows onto the part or mold surface so entrapped air and inner band gaps are removed from the band width. . . . In most situations it is necessary to introduce heat into the compactor nip area to decrease the resin viscosity of the tows. This part of the process is referred to as tack enhancement. Heat promotes resin flow thus enabling the compactor to remove gaps between adjacent tows easier. Increased tack also enables the incoming fibers to adhere more quickly and remain in place on the mold or previously laid courses.

Thus, Evans discloses that applying heat during compaction enhances tack and enables the tows to adhere to the mold surface more effectively. However, Evans does not suggest passing the tows through a preheating zone of a fiber placement apparatus prior to compaction.

Sherwood discloses a method of fabricating reinforced plastic pipe or other tubular articles using a filament or tape winding apparatus. See Answer, p. 6. The apparatus includes a rotatable reel 2 on which a coil of tape 3 is mounted. The tape 3 is guided onto a mandrel 4 in a generally helical pattern by a guide mechanism 5 which serves to properly guide the tape and impart a selected twist to the tape as it moves from the coil on reel 2 to the mandrel. See col. 2, lines 30-41.

The tape is formed of a reinforcing material and is impregnated or coated with a thermosetting resin (col. 3, lines 18-27):

> The resin is applied to the reinforcing material in any conventional manner such as dipping, spraying, roller coating, and the like. After the resin and curing agent are applied to the reinforcing material, the resin will begin to cure or polymerize and the curing of the resin is halted at a predetermined stage by refrigerating the tape so that the resin will be in the solid partially cured state and will not be full cured to the infusible state. The tape can then be wound in coiled form on reel 2 in preparation for the pipe fabricating process.

During the fabrication process, the partially cured thermoset resin may be melted by passing the tape over a heated distribution roller 21 located proximate the mandrel 4 or by heating the mandrel itself. See col. 1, lines 23-26.

Chitwood is directed to a tape laying machine employing filamentous tapes. The tapes comprise unidirectional, tectonic filaments or fibers which are preimpregnated with a matrix of any organic, thermosetting resin. See col. 2, lines 8-35. According to the process of Chitwood, the tape is unwound from a spool and fed beneath a detrusion nozzle where it is detruded onto the face of a die pattern. At the detrusion nozzle, the tape is subjected to the detrusion pressure of a single large jet of air, or alternately, of a multiple of small high pressure jets. The pressurized air may be preheated for the purpose of inducing tackiness in the resinous matrix of the tape or to cure the resin at the time the tape is laid down. See col. 6, lines 29-37; col. 8, lines 20-45.

Hebert discloses a filament preheat apparatus which is mountable to the payout assembly of a filament winding machine. According to Hebert (col. 1, lines 14-45):

> [D]uring a winding process involving preimpregnated or "prepregged" materials, such as resinous filaments, for example, the material is fed from some sort of payout assembly to a mandrel. . . .
>
> When prepregged materials are wound it is generally desirable to preheat both the material and mandrel. Preheating causes better material compaction, which thereby produces a higher quality finished product. In the past, preheating has been accomplished

> by an operator who manually holds a conventional heat gun near the mandrel at the point of winding. . . .
>
> The present invention eliminates these drawbacks by providing a preheat apparatus that is directly mounted to the winding machine's payout assembly.

Specifically, the apparatus disclosed in Hebert has heating tubes or electric torches that deliver a heated airflow of variable heat flux into a duct. The exit end of the duct is positioned near the filament and mandrel and preheats both during winding. See Abstract.

Neither Sherwood, Chitwood nor Hebert discloses a fiber placement apparatus. Furthermore, neither Sherwood, Chitwood nor Hebert discloses passing a thermoset resin impregnated fiber tow or tape through a preheating zone prior to laying up the fiber tow or tape on a mandrel.

Similarly, Boss is not directed to a fiber placement apparatus. Rather, Boss discloses a method of making impregnated fibers which are intended to be used in filament winding or other suitable techniques. According to Boss (col. 1, lines 41-64):

> Carbon fiber reinforced composites are commonly formed by coating or impregnating carbon fibers with an uncured or partially cured liquid thermosetting resinous material which is ultimately to serve as the matrix or continuous phase in the composite article, converting the resinous material present on the carbon fibers to a tacky consistency through partial curing and/or evaporation of solvent, molding or otherwise

> shaping the same into the desired configuration, and fully curing the same to form a rigid monolithic structure. . . . Whenever filament winding is utilized to shape the composite article, the resin impregnated carbon fibers bearing a partially cured resin must by necessity be provided in an appreciable length. The efficient uniform resin impregnation, handling, and partial curing of continuous lengths of carbon fibers particularly in ribbon form has been an elusive goal when employing prior art technology.

Boss discloses an improved process for producing a continuous length of a carbon fiber ribbon which is impregnated with a tacky B-stage thermosetting resin. Specifically (Abstract):

> The fibrous ribbon undergoing treatment is resin impregnated with a neat liquid resin system of relatively high viscosity containing an A-stage thermosetting resin through the application of a force sufficient to bring the resin into intimate association with the individual fibers of the ribbon. The resin impregnated ribbon is next partially cured while continuously passing through a heating zone as described while interposed between a pair of flexible endless belts.

The resulting ribbon is continuously withdrawn from the heating zone prior to a point in time when the thermosetting resin is advanced to a hard non-tacky C-stage consistency. The resin in intimate association with the ribbon remains in a tacky B-stage consistency at the time of its withdrawal from the heating zone. The ribbon may be collected or directly utilized in the formation of carbon fiber reinforced composite structures using conventional filament winding, molding or shaping techniques. See col. 8, lines 45-55; col. 9, lines 15-18.

The examiner recognizes that Boss does not mention a fiber placement operation. See Answer, p. 35. Nevertheless, the examiner argues (Answer, pp. 10-11):

> [Boss] clearly describe[s] a process of partially curing a resin impregnated tape or tow in a system for forming a composite structural article for the aerospace industry where the tow or tape is filament wound (a form of "fiber placement"), molded, or otherwise shaped subsequently to partial curing of the tape or tow in the system. Because it would have been viewed as a useful means for forming a resin impregnated partially cured prepreg tape which was fed directly into a fiber placement device (and noting that whether one formed partially cured prepreg material or supplied the prepreg from a roll stock of material was within the purview of the ordinary artisan) where the tape was formed into the prepreg by heating to advance the cure of the same and then fed directly into a fiber placement device (in a preheated state) wherein the tape would have been applied in the usual fashion, it would have been obvious to one of ordinary skill in the art at the time the invention was made to utilize the techniques of Boss when making a composite article where a thermosetting resin impregnated fibrous material was applied to a form and cured in situ during lay down as suggested by Chitwood et al . . . .

Moreover, this panel in its prior decision stated (Paper No. 25, p. 7):

> Both Sherwood and Boss disclose that partially cured resin impregnated fiber reinforced ribbons or tapes are useful in a <u>filament winding process</u>. Furthermore, both Sherwood and Boss recognize that thermoset resins may be used to impregnate the

> reinforcing material. Therefore, it would have been obvious to one having ordinary skill in the art to partially advance the curing of a thermoset resin impregnated fiber tape in the winding process disclosed in Sherwood in a preheating zone as disclosed in Boss. [Emphasis added.]

However, subsequent to the prior decision, appellants amended claim 1 to include the limitation of "passing the at least one thermoset resin impregnated fiber tow or tape through a preheating zone <u>of a fiber placement apparatus</u> to preheat the thermoset resin impregnated fiber tow or tape . . . " (emphasis added). See also claim 32. As discussed in Evans, filament winding is not "a form of 'fiber placement' " as alleged by the examiner but rather is "a unique method of laminating prepregged fiber materials onto a complex mandrel or mold." See Evans, page 2, col. 1. Neither Sherwood, Boss, Chitwood nor Hebert discloses a fiber placement apparatus.

To the extent that Boss suggests preheating a resin impregnated fiber tow or tape prior to its use in the formation of carbon fiber reinforced composite structures, we agree with appellants that (Brief, pp. 26-27 and 52):

> At best, in combining Boss with Sherwood [, or for that matter, Evans, Chitwood or Hebert], one of ordinary skill in the art might consider *replacing* the heating means of Sherwood with the heating zone of Boss if the heating zone of Boss could prove effective in imparting tack or initial adhesion to the fiber tows or

> tape. However, there is no teaching or suggestion to utilize multiple means of heating *in close sequence* to effect curing *in situ* as recited by claim[s] 1 [and 32].

In sum, none of the references relied on by the examiner, either alone or in combination, suggest passing a thermoset resin impregnated fiber tow or tape through a preheating zone of a fiber placement apparatus prior to laying up the fiber tow or tape on the mandrel as claimed. Therefore, the rejections of claims 1 and 32 are reversed. Since claims 2 through 11 and 14 through 31 depend on claim 1, the rejections of claims 2 through 11 and 14 through 31 are also reversed.

REVERSED

EDWARD C. KIMLIN Administrative Patent Judge	)
ADRIENE LEPIANE HANLON Administrative Patent Judge	) BOARD OF PATENT APPEALS AND INTERFERENCES
CHUNG K. PAK Administrative Patent Judge	)

ALH:svt

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